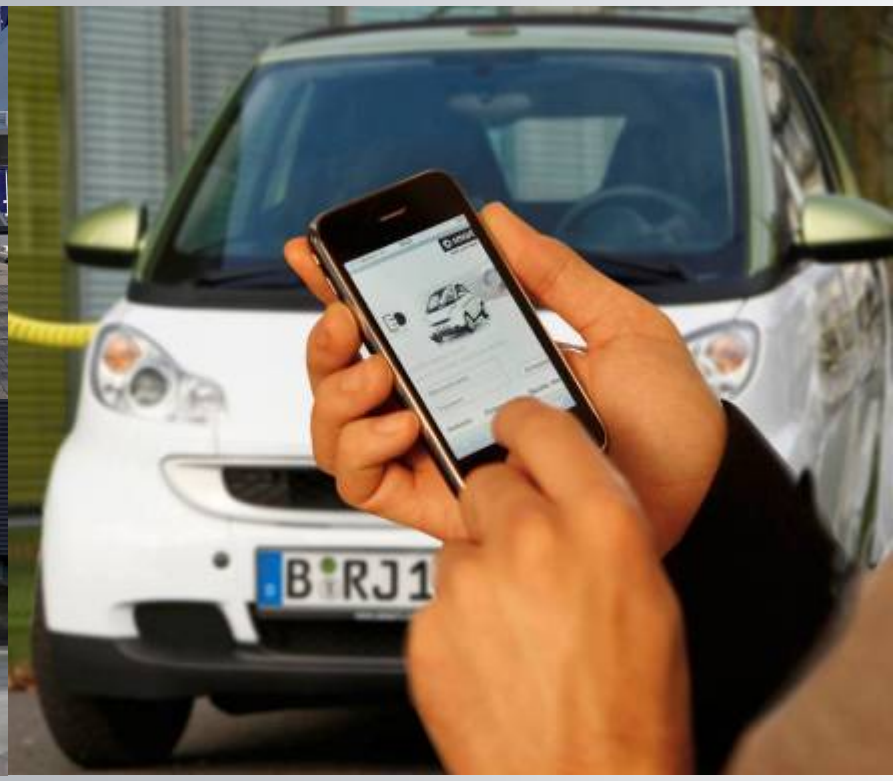
Mercedes-Benz

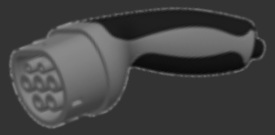

# E-Mobility – Vehicle2Grid interface (Schnittstelle zwischen Fahrzeug & Infrastruktur)

5. Vector-Kongress 2010
Christoph Saalfeld
Daimler AG
Stuttgart, 01.-02.12.2010

# Agenda

1. Use-cases for vehicle to grid (V2G) communication
2. Vehicle-to-grid communication standards
3. Charging infrastructure architectures for plug-in electric vehicles
4. The vehicle to grid communication interface protocol stack

# Household sockets cannot deliver the power needed to meet customer expectations

| | | | | |
|---|---|---|---|---|
| NEMA 5-15 |  | 1,4 kW | 14h | 38h |
| CEE 7/7 |  | 2,3 kW | 8h | 23h |
| IEC 62196-2 Type 1 (≈J1772™) |  | 7,7 kW | 2,5h | 7h |
| IEC 62196-2 Type 2 |  | 44 kW | 30 min. | 1,2h |

# Charging times will not reach refueling times of internal combustion engine (ICE) vehicles

Refueling time of ICE vehicle

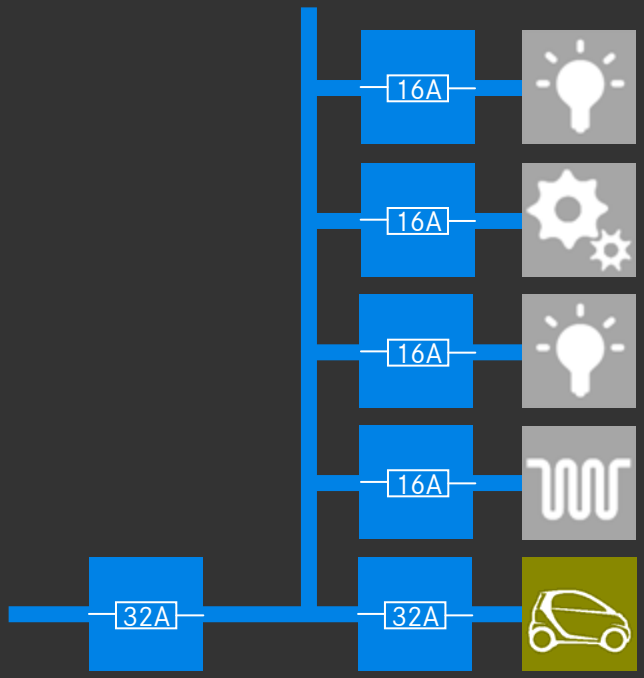
- Flow rate of filling station ca. 10 gallons per minute
- Fuel efficiency of ICE vehicle ca. 30 mpg
- Refueling time ca. 20 seconds for 100 miles

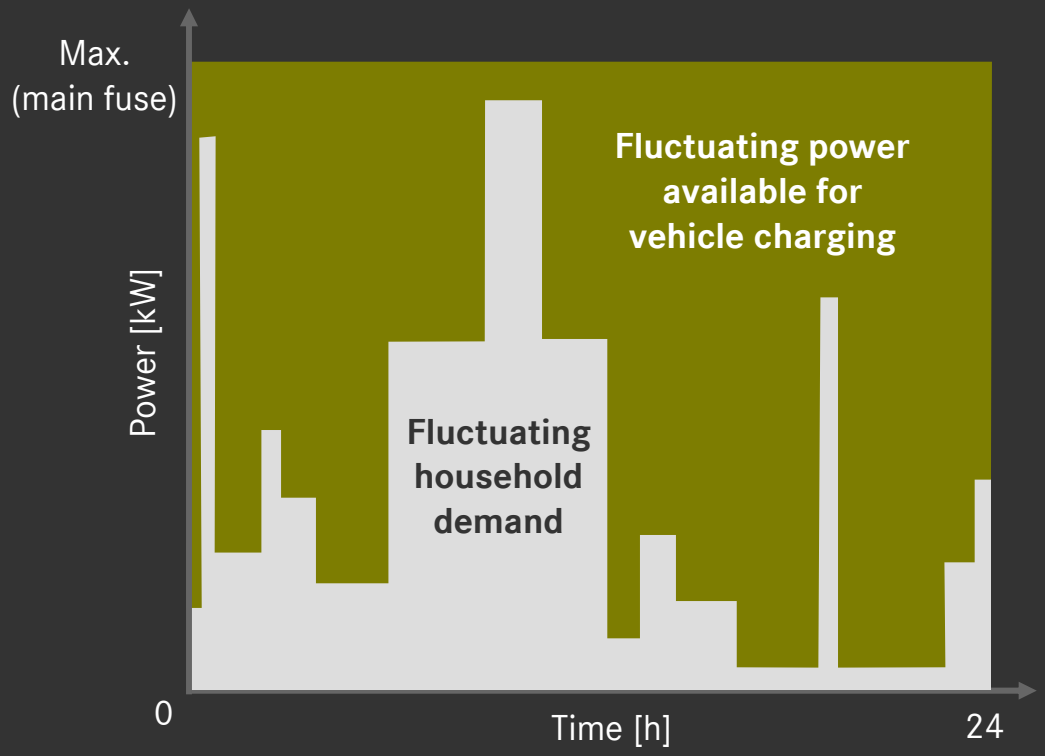
Power needed to refuel an EV as fast as an ICE vehicle

- Energy consumption approx. 25 kWh for 100 miles
- Refueling time same as ICE vehicle
- Required charging power ≈ 5 MW

# What would be the total re-charging time of the last car in the row?

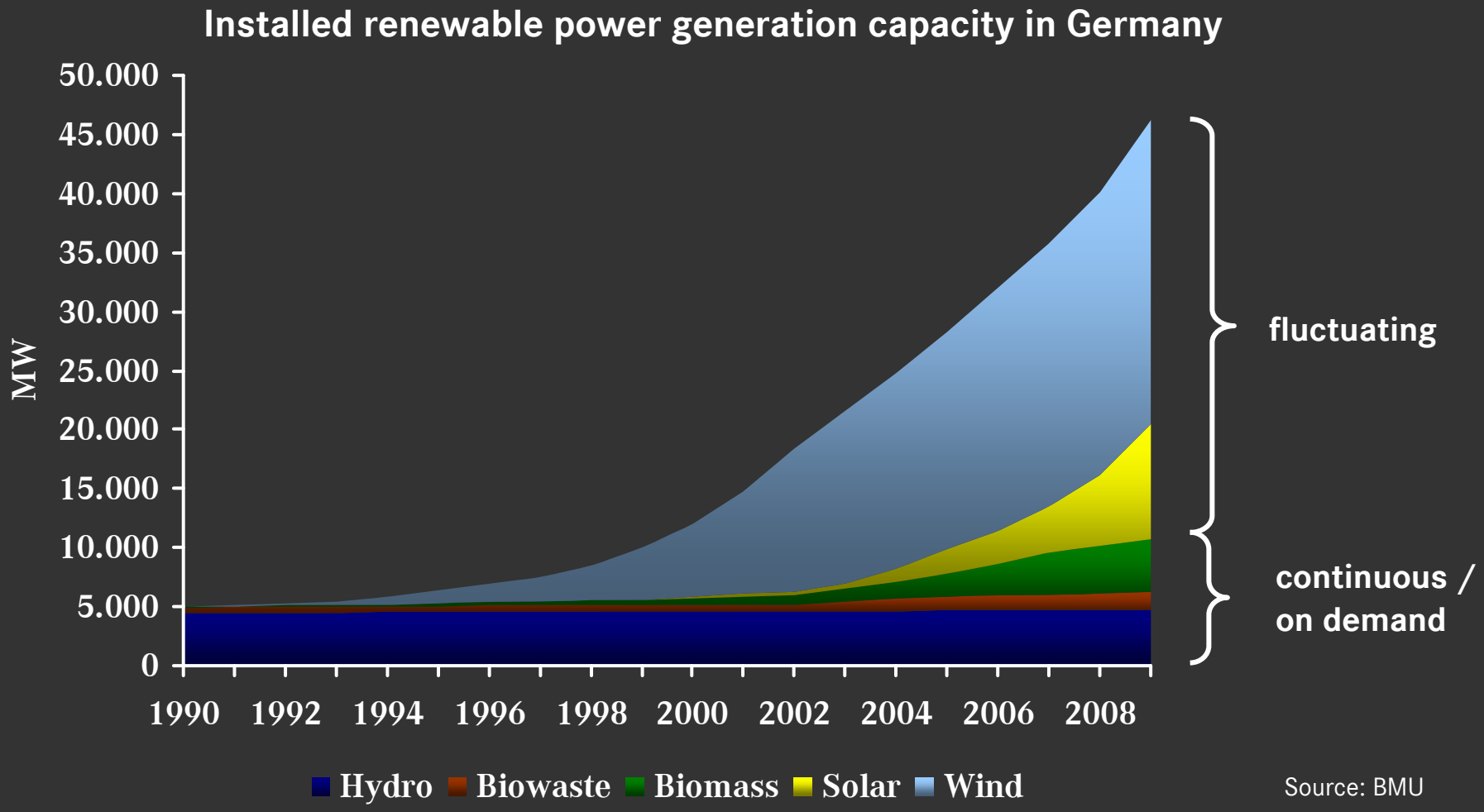
# Especially in countries with low power household service connections, load management will first become necessary within the home




**Immediate reduction of charging power if total consumption is exceeding the limit of service connection**

# To efficiently use renewable electricity charging strategies have to adapt to the fluctuating supply



# Payment and billing of electricity

- Total cost for recharging low compared to refueling
  - Refueling 50…100€ in 3..5 minutes
  - Full re-charge 4…6€ over 2…8hours → Micro payments

- Public charge spots most likely not in monitored areas
  - charge spots must be protected against vandalism
  - tamper-resistant payment system required

- RFID solutions
  - many systems available which partially interfere with each other
  - RFID-card requires interaction of driver with charge spot upon charge-initiation and cannot handle automatic restart after power-outage

**→ Automatic and cost-efficient payment solution required**

# Remote vehicle status information and control will be essential for customer acceptance of battery and grid optimized charging

**Status information**

- Current state of charge
- Predicted end of charge
- Charge interruption warning
- Vehicle position
- …

**Set parameters**

- End of charge target
- Required range
- Cabin preconditioning
- …

# Summary – Use-cases for V2G communication

SmartCharging System

**Simple payment & billing**

- Automatic payment from PEV
- Access to all charging stations with one contract (Roaming)
- Secure payment via state-of-the art signatures & certificates

**Optimized load management**

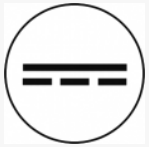
- Cost-optimized (e.g. night tariff) and battery-optimized (SoC, charging power, temperature) charging
- Support of renewable energy in the grid for emission-free driving
- Fleet-management for areas with high density of PEVs

**Additional PEV-customer services**

- PEV status information (current SoC, remaining charge time..)
- Remote control of charging (e.g. departure time)
- Access to internet-based services (e.g. diagnostics, software updates, etc.)

**DC-Charging Control**

- Authentication of certified off-board charging equipment
- Charge-control via voltage and amperage control commands
- Re-usage of communication technology for AC & DC-charging



# Communication between the vehicle and the infrastructure will be needed for safety, load management and billing

**Grid**

**Charge spot**

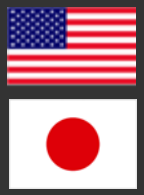
**Vehicle**

| | | |
|---|---|---|
| | 1 ← | Cable safety test successfully completed, please lock my charge cord |
| I can deliver up to 22kW | 2 → | |
| | 3 ← | Here's my ID, I am an authenticated PEV and I would like to charge |
| Valid ID, please go ahead, power will be activated | 4 → | |
| Here are the power levels & prices over time for your needs + special rate for wind-power of up to 10kW between 3am to 6am for 3cents/kWh | 5 ← | I need 12kWh to fully recharge until 9am next morning |
| | 6 → | |
| | 7 ← | O.K I adjust my plans and will charge from 3am to 5am at 6kW |
| So far I delivered 5kWh to you, please confirm | 8 → | |
| | 9 ← | I confirm to have received ca. 5kWh |
| | 10 ← | I want to leave, please unlock the charge cord |

# All relevant areas are covered in Europe through ISO/IEC standards

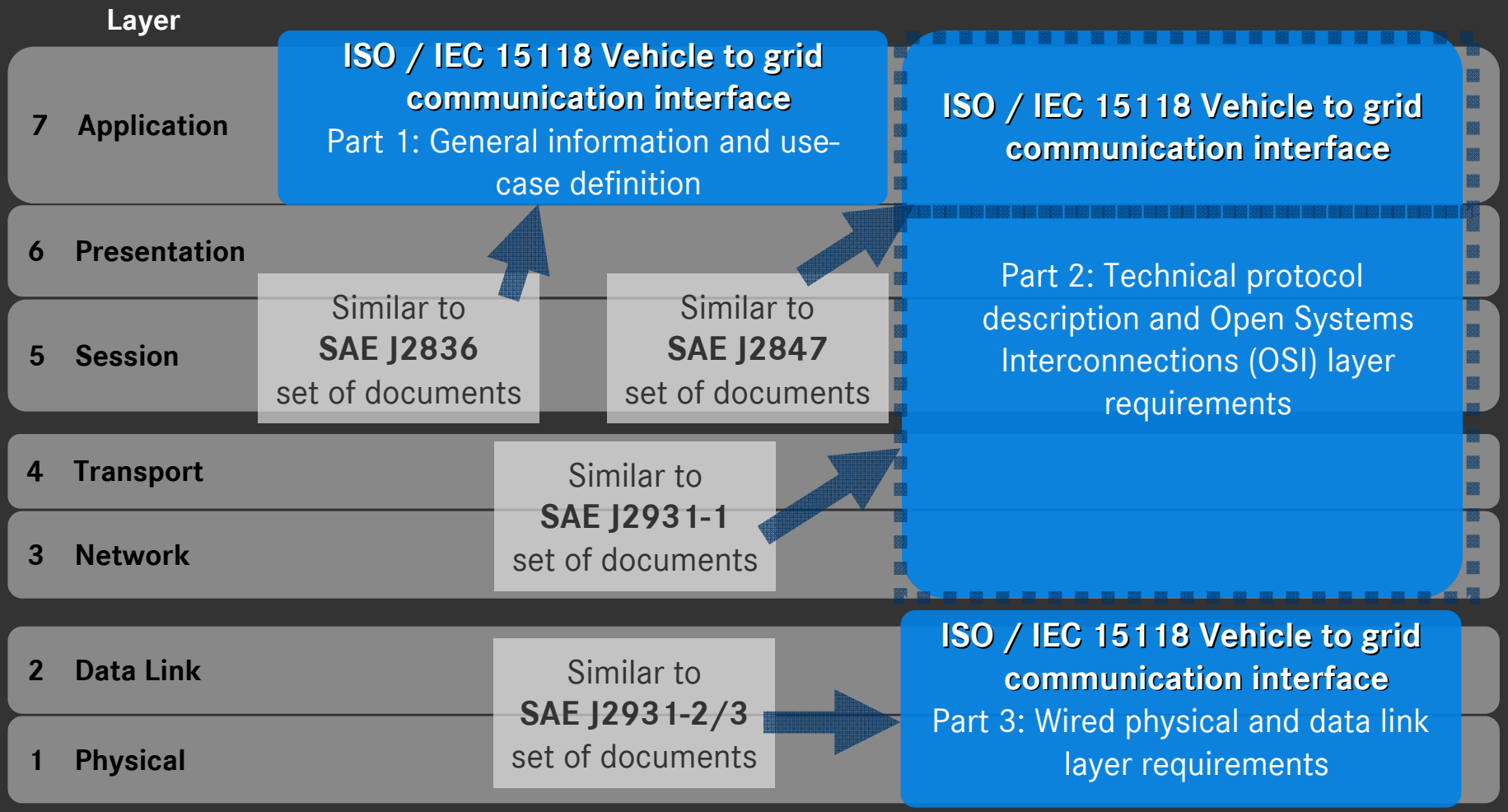
| | | |
|---|---|---|
| **Connector**  | IEC 62196-2 | • Plugs & socket outlets<br>• vehicle-couplers and vehicle inlets |
| **Communication** IEEE | ISO/IEC 15118 | • Road vehicles - Communication protocol between electric vehicle & grid<br>• Part 1: General information & use-case definitions<br>• Part 2: Technical protocol description and Open Systems Interconnections (OSI) layer requirements<br>• Part 3: Wired physical and data link layer requirements |
| **Safety**  | IEC 61851 | • Electric vehicle conductive charging system<br>• Part 1: General requirements<br>• Part 21: Electric vehicle requirements for conductive connection to an AC/DC supply<br>• Part 22: AC electric vehicle charging station |

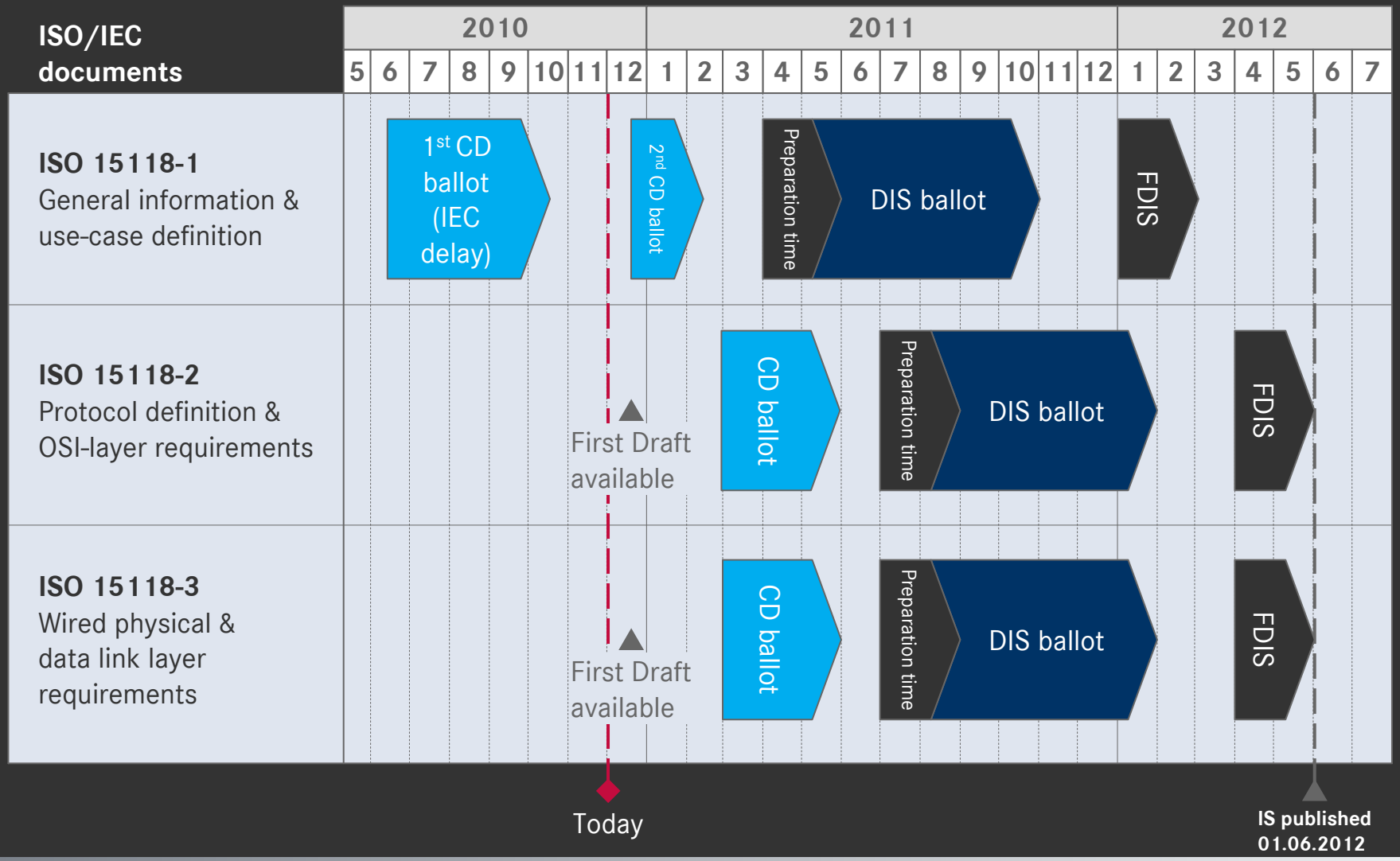
# Combo-Connector for both AC- & DC-Charging without separate pins for communication

| | | AC | | DC | |
|---|---|---|---|---|---|
| | | 1-phase | 3-phase | low | mid |
|  | USA/ Japan | Type 1  | *(Infrastructure not available)* | Type 1  | Type 1 Combo  |
|  | Europe/ China | Type 2  | Type 2  | Type 2  | Type 2 Combo  |

➔ Communication over **Mains (AC)** or **Un-used mains (DC)** or "in-band" on **Control Pilot (AC or DC)** or **Plus and Minus (DC)**

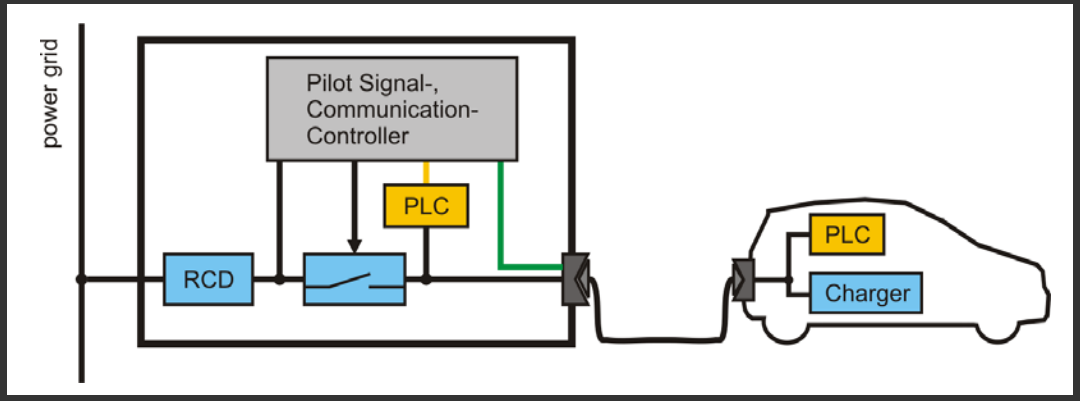
# ISO/IEC 15118: Road vehicles – Communication protocol between electric vehicle & grid - document structure



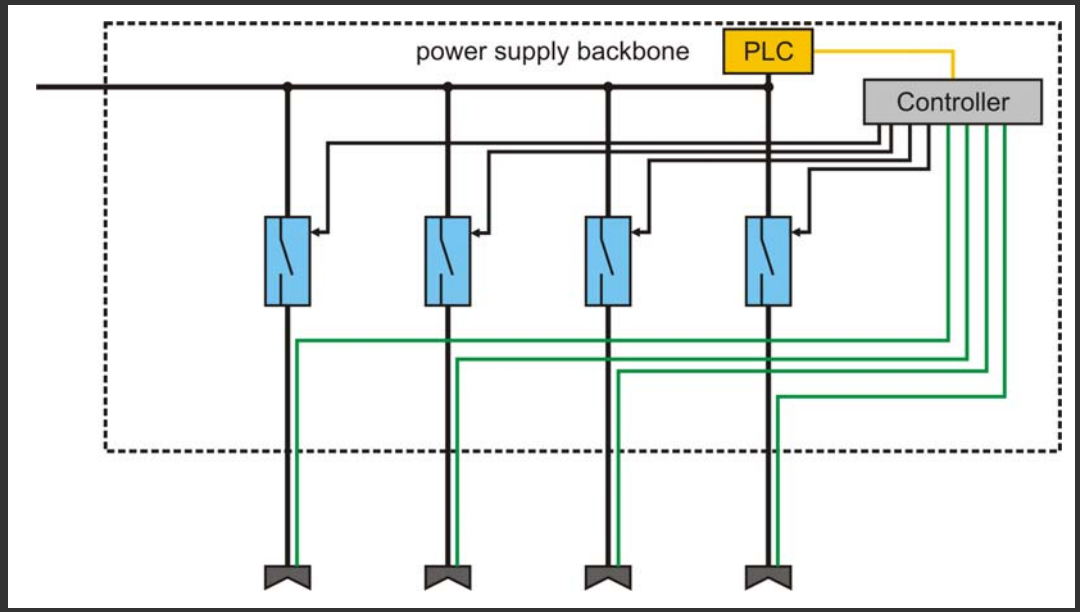

ISO/IEC documents
2010
2011
2012
5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7
ISO 15118-1
General information & use-case definition
1st CD ballot (IEC delay)
2nd CD ballot
Preparation time
DIS ballot
FDIS
ISO 15118-2
Protocol definition & OSI-layer requirements
First Draft available
CD ballot
Preparation time
DIS ballot
FDIS
ISO 15118-3
Wired physical & data link layer requirements
First Draft available
CD ballot
Preparation time
DIS ballot
FDIS
Today
IS published 01.06.2012

# Architecture 1: Intelligent EVSE

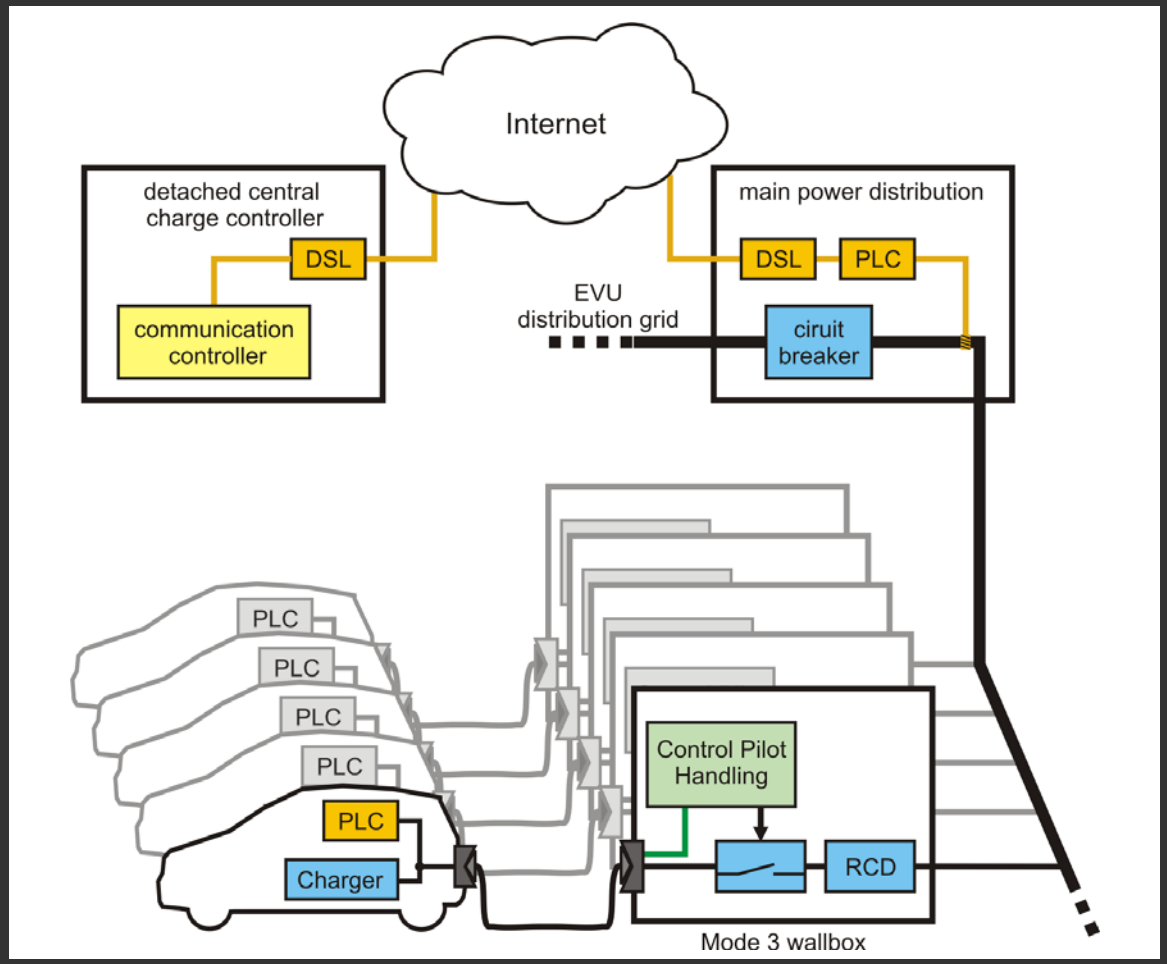
- **Option 1:** EVSE with only one charge outlet (e.g. in private garage)



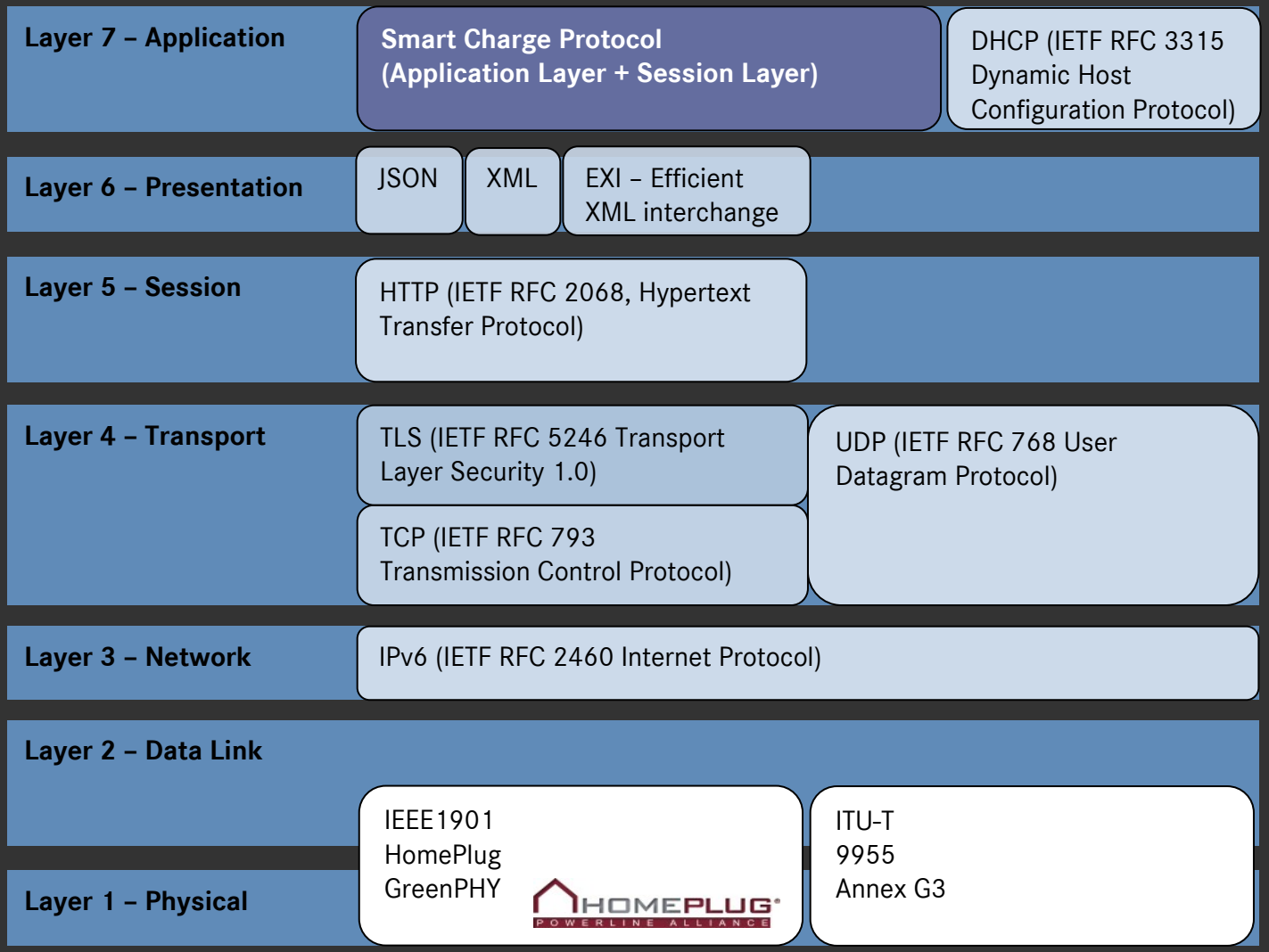

- **Option 2:** EVSE with multiple charging outlets (e.g. curb-side public charging station)

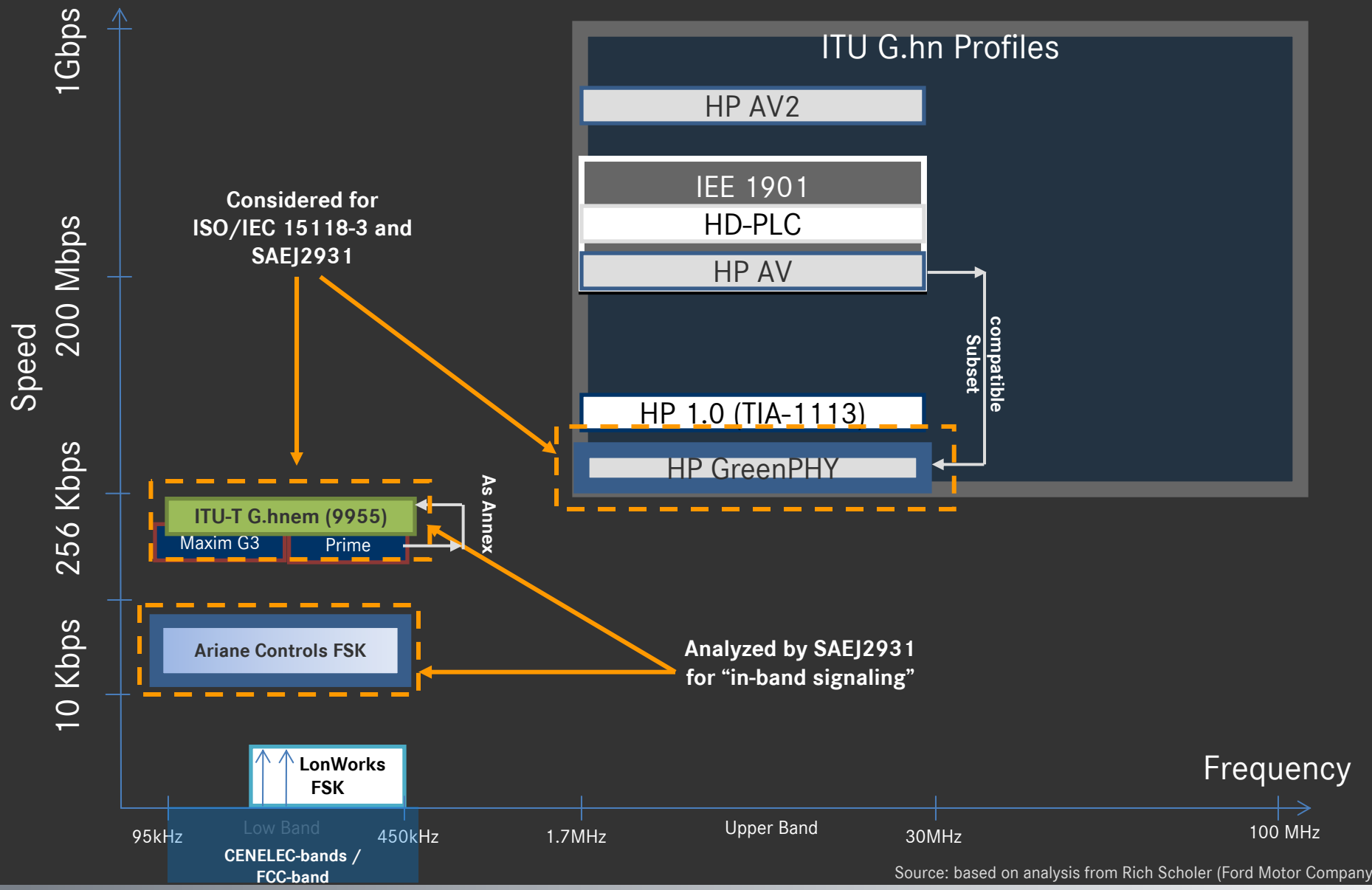


# Architecture 2: Local non-intelligent EVSEs with detached intelligent control unit (e.g. fleet management or parking garage)



# Layered architecture of V2G communication protocol stack






Source: based on analysis from Rich Scholer (Ford Motor Company)

# Comparison of PLC-technologies

| | | HomePlug GreenPHY | | ITU-T9955+Annex G3 |
|---|---|---|---|---|
| **Bandwidth** | ++ | High & scalable (1MBit…10Bit/s usable) | - | Low (40..200kbit/s usable → slower than CAN) |
| **Frequency & EMC** | + | Broad, very stable | - | Narrow, may be impaired by DC-charging |
| **Countries** | – | Currently not allowed in JP, de-regulation ongoing | + | Allowed, frequency-band may change per country |
| **Charging setups** | + | Point-to-point public/private + economic fleet/parking garage charging | - | Always point-to-point wall-box required |
| **Availability** | - | Migration technology available, Chip being developed & qualified with German OEMs | – | Standard not finished, Chip to be developed & qualified |
| **Future proof / other use-cases** | ++ | Open for home-network integration & SmartGrid compatible | + | Further use-cases limited no integration into SmartGrid |

# Summary – V2G Communication protocol stack

- Standards are necessary to…
  - Enable interoperability of all PEVs with all types of PEV charging equipment in public or private areas
  - Enable systems for automatic load leveling and renewable energy flow control
  - Provide methods for automatic electricity payment and billing systems
  - Pave the way for additional internet-based services for PEVs

➔ **IT-network technologies are introduced into PEV embedded components in order to support the charging use-cases**

➔ **A standardized protocol stack implementing the V2G protocol is highly recommended to increase interoperability of PEVs and charging infrastructure**

➔ **Standardized tests will be required to ensure V2G protocol compliance of PEVs and charging infrastructure**

➔ **Daimler substantially contributes to the new ISO/IEC communication standard for PEVs based on their implementation from "e-mobility Berlin"**

Thank you for your attention!